1,044,031

PATENT SPECIFICATION 1,044,031

DRAWINGS ATTACHED.

Date of Application and filing Complete Specification:
March 28, 1963. *No. 12304/63.*

Application made in United States of America (No. 188,111 on April 17, 1962.

Complete Specification Published: Sept. 28, 1966.

Index at Acceptance:—B5 A(1R14A, 1R14C2, 1R14D); B5 N(1A, 2C, 2F, 2H, 2K1C, 5G6, 11K1, 16B3, 18).

Int. Cl.:—B 29 d, g //B 32 b.

COMPLETE SPECIFICATION.

Production of Articles Composed of Fiber Reinforced Resin Materials.

We, UNIVERSAL MOULDED FIBER GLASS CORP., a company organised and existing under the laws of the State of Delaware, United States of America, of Commonwealth Avenue, Bristol, State of Virginia, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to production of articles composed of fiber reinforced resin materials and is especially concerned with an improved method and apparatus for making such articles by the type of operation according to which fiber reinforcement impregnated with a heat hardenable resin is drawn through the confining passage of a die structure in which the resin is hardened by heating.

More particularly, the invention is concerned with the regulation or control of the curvature of the article delivered from the exit end of the confining passage through the die structure. The term "curvature" in the present invention excludes a substantially straight line.

One of the important objects of the invention is to provide for the continuous production of articles by the type of technique above referred to in which the article is curved, rather than straight, whereby articles may be made by this type of technique which would be suitable for use as structural parts wherever curvature is needed, for instance in certain types of moldings adapted to be applied to circular or cylindrical structures, the slats of chair seats or chair backs, etc.

Prior proposals refer to an apparatus for forming articles composed of fiber reinforced resin materials, which comprises a forming device having an elongated confining channel therein including a portion of substantial length having a uniform cross section throughout the length thereof, a resin bath for a heat hardenable liquid resin material, and means for drawing reinforcing fibers through said bath and through said channel, the channel further having an entrance end portion tapered to an inlet opening of enlarged size, so that the impregnated fibers are progressively confined as they are drawn through the entrance end portion of the channel, and the resin bath being positioned in relation to the inlet opening of the channel in the forming device so that excess resin material ejected out of said entrance end returns into said bath, and means being provided for maintaining the entrance end portion of said channel at a temperature sufficiently low to substantially preclude hardening of the liquid resin material which is ejected and returned to the resin bath.

According to the present invention a method for forming a continuous length of articles composed of fiber reinforced resin materials comprises the steps of impregnating the fiber reinforcements with a heat hardenable liquid resin material, feeding the impregnated fiber reinforcements into the entrance end portion of a confining passage, heating the resin material in at least a portion of the confining passage to a temperature sufficient to solidify the resin and pulling the solidified article beyond the exit end portion of the confining passage at an angle deviating from a straight line extended along the line of discharge of the hardened article from the exit end to impart to the article a desired curvature.

The present invention also refers to an apparatus for forming articles composed of

[*Pric*

fiber reinforced resin materials, which comprises a forming device in the shape of an elongated confining channel having a center line, the channel having an entrance end portion and an exit end portion, heating means located intermediate said entrance and exit end portions for solidifying the resin while travelling through the forming passage and pulling means for drawing the fiber reinforcements together with the resin through said confining channel, said pulling means being arranged at an angle from the center line of the confining passage to impart a predetermined desired curvature to the article.

With certain types of die structure and puller mechanism articles may be formed having controlled and highly accurate curvature in a certain desired direction or plane, and thereby pieces may be made by this continuous process, which are adapted for uses where curved structures, decorative or otherwise are needed.

In the accompanying drawings:

Figure 1 is a small scale overall elevational view, with parts shown only diagrammatically, illustrating the overall arrangement of one embodiment of the apparatus;

Figure 2 is an enlarged view of parts shown in Figure 1, certain parts being broken out and with the die structure and resin pan shown in vertical section;

Figure 3 is a plan view with parts in horizontal section corresponding to certain portions of Figure 2;

Figure 4 illustrates a channel member formed by the process of the present invention and indicates a type of curvature which is sometimes desired;

Figure 5 is a further enlarged elevational view of certain parts shown in Figures 1, 2 and 3 and particularly illustrating the manner of relative positioning of certain of those parts for the purpose of obtaining the desired curvature;

Figure 6 is a view similar to Figure 4 but illustrating a desired curvature of a channel member in a different plane;

Figure 7 is a view similar to Figure 5 but showing the apparatus, in plan rather than in elevation and illustrating the parts in position for obtaining the required curvature of the kind shown in Figure 6;

Figure 8 is a transverse sectional view through the formed article such as in Figure 5, and illustrating the gripping elements of the puller mechanism in relation to the formed article;

Figure 9 is a fragmentary elevational view similar to parts shown in Figure 2 but illustrating an alternative embodiment of the puller mechanism;

Figure 10 is a plan view of certain of the parts shown in Figure 9 and illustrating arrangement of those parts so as to produce the article having the desired curvature;

Figure 11 is a view similar to Figure 8 but illustrating the modified form of puller mechanism of Figures 9 and 10; and

Figure 12 is a view of another embodiment of the gripping elements of the puller mechanism.

Referring first to the embodiment referred to in Figures 1 to 8 inclusive, it will be seen that the equipment includes a puller mechanism comprising a pair of crawler treads cooperating with each other to grip the piece or article being formed therebetween and effect the feed of the materials and also of the piece formed through the forming device.

This crawler tread mechanism is diagrammatically indicated in Figure 1 at CT. Figure 1 also shows that the puller mechanism is mounted on a frame structure including supports 13 which are firmly mounted on a foundation such as the floor 14. The puller mechanism is driven by means of a motor 15 through speed reduction mechanism 16 and transmission units enclosed in casing parts 17, the details of this drive mechanism not being illustrated or described herein as they form no part of the present invention per se.

From Figure 1 it will further be observed that the puller mechanism includes longitudinal main frame members such as shown at 18 (see also Figure 2) carrying at one end (the right hand end in Figures 1 and 2) a thrust carrying abutment or bracket structure 19 supporting an abutment or thrust plate 20 which serves as a mounting means for the forming device, as will be described herebelow with more particular reference to Figures 2 to 7 inclusive.

The forming device, which is generally indicated at FD in Figure 1 is mounted upon a bracket 21 which in turn is secured to and supported by the thrust plate 20 above mentioned. The resin supply or pan 22 is mounted on the end of the forming device remote from the puller mechanism, and fiber reinforcement, such as strips of mat or woven glass fiber material 23, is fed into the pan and into the forming device, there being three such strips here shown, the supply spools 24 for only two of which appear in the figure. These supply spools may be supported in any convenient manner as by one or more upright post supports 25 which are adjustable toward and away from the remainder of the apparatus along the base guideway support 26 anchored or otherwise supported on the floor 14.

As best seen in Figures 2, 4 and 5, the apparatus of this embodiment is illustrated as constructed to produce a channel piece having a base or web 27 and side flanges 28. For this purpose the forming device comprises upper and lower mating die parts

forming a channel-shaped confining passage therebetween corresponding to the shape of the channel to be formed. These upper and lower die parts are indicated at 29 and 30 in Figure 2. The upper part 29 comprises a channel structure, adapted to fit over the upper central portion of the lower die part thereby forming a channel-shaped passage between the two die parts adapted to act as the confining passage for the channel shape desired.

As will be seen in Figures 2 and 5, the entrance end portion of the upper die part 29 is cut away or tapered at 31 in order to provide a tapered inlet end portion for the confining passage between the two die parts. The remainder of the passage formed between the two die parts is preferably of substantially uniform cross-sectional dimension.

As will be seen from Figure 2, the fiber reinforcement strips 23 are fed into the resin pan 22 over the end wall thereof and thence pass under an arcuate guide 32. From this guide the strips pass through the resin in the bath to the entrance end of the confining passage in the die in which the strips are partially folded, so to speak, in order to deflect the marginal portions of the strips downwardly so as to lie in the planes of the flanges of the channel to be produced. This action is indicated by the divergent lines extended from the guide 32 to the entrance end of the die in Figure 2. During the course of the traverse of the webs through the resin pan, the webs lie within the resin bath itself, preferably entirely below the surface thereof, and as will be seen from Figure 2, the level of the resin bath is desirably kept at least as high as the uppermost portion of the flared or tapered entrance end of the confining passage in the die. In this way the fiber reinforcement is always effectively impregnated with excess resin material which, as the feed progresses and the impregnated material is compressed or compacted, is expelled from the entrance end of the die to return to the body of the resin in the resin pan.

The crawler treads of the puller mechanism as shown to the left of Figure 2 includes upper and lower mating shoes 33 and 34 which are shaped to respectively engage the upper and outside surfaces and the lower and inside surfaces of the channel being formed. This puller mechanism therefore tightly grips the channel piece being formed and is capable of exerting a large pull on the formed piece so as to move the piece through the forming device as it is being formed and also feed the reinforcement from the supply reels to and through the resin bath and into the die. The thrust or load is directly carried from the puller mechanism through its frame structure by means of the thrust bearing bracket structure 19 and the thrust plate 20, to which the forming device is fastened.

Each of the gripping elements or shoes 33 and 34 of the crawler mechanism is preferably provided with a friction, for instance rubber, surface or lining 35. As seen in Figures 2 and 8, the lower shoes 34 interfit with the inside of the channel being formed and thus effectively position the channel piece against creeping or curvature laterally.

From Figure 2 it will be seen that the parts of the die structure are provided with means for cooling and heating various regions of the die parts, as will now be explained.

Toward the entrance end of each of the die pieces 29 and 30, circulating passages are provided in the upper die piece 36 and in the lower die piece 37. These provide for the circulation of a cooling liquid, for instance, water either at normal supply temperatures or cooled or refrigerated as needed in order to cool the entrance end portion of the die structure. It may here be noted that the portions of the die structure surrounding the entrance end opening of the confining passage are actually directly exposed to the resin in the resin bath. Stated in another way, the entrance end portion of the forming device constitutes a part of the wall of the resin bath. This is of advantage in providing for entrance of the fiber reinforcement into the confining passage in fully impregnated condition, but in this situation, cooling of the entrance end portion is of special importance because of the possibility for direct heat transfer between the die and resin in the bath, which would cause premature setting of the resin in the resin pan. Also the cooling of the entrance end portion serves to avoid return of partly cured resin from the entrance end of the die back into the reservoir, when the excess of resin is expelled from the entrance end of the die as a result of the compressing or compacting action of the die upon the impregnated fiber reinforcement entering the die.

With thermosetting resins, for instance of the kind hereinafter referred to, it is desirable to maintain the entrance end portions of the die at a temperature below about 130° F.

The mid section of the two die parts 29 and 30 is heated, and for this purpose, the die parts 29 and 30 are provided with recesses or cavities such as shown at 38 and 39 in which electrical heating elements may be disposed.

The exit end portions of the die parts 29 and 30 are also provided with passages 40 and 41 for the circulation of a cooling

medium or liquid, such as water, which is advantageous in certain cases in order to reduce the temperature of the cured or formed piece below the heat distortion point before the formed piece is extracted from the forming device by the puller mechanism.

In the production of channel-shaped pieces, and especially with certain types of fabric reinforcement employed in making the channel piece, there is sometimes a tendency for the channel piece to distort or warp or curve as it is being formed, particularly in instances where the rate of production and the temperatures are not such as to effectively reduce the temperature of the entire piece below the heat distortion point before delivery from the die. Such fortuitous distortion or warpage in one plane or another has to be corrected since the amount of warpage cannot be predicted.

The arrangement of the present invention is, on the other hand, arranged to give a predetermined curvature to the article produced so that the article can be utilised for the intended purpose, which requires a predetermined curvature in a given plane.

The position of the apparatus enabling a channel member to be obtained having a curvature 180° off-set from the curvature shown in Figure 4 is illustrated in Figure 5. The angular relationship of the pulling mechanism from the central axis of the forming passage or die is other than 180°, as illustrated in Figure 5, this angle being less than 180° when measured inside the channel shape in a plane perpendicular to the base or web of the channel. Although for a channel of given size and type, this angle may be preset, i.e. may be built into the apparatus, the apparatus advantageously includes a mechanism for varying the angle between the die axis and the line of pull. This is accomplished in the embodiment here illustrated by adjusting the angle of mounting of the forming device on the thrust carrying bracket structure 19—20. Specifically, the die mounting bracket 21 as will be seen in Figures 5 and 7 is connected to the thrust plate 20 by means of bolts 42 having heads engaged in the plate 20, together with angle adjusting screws 43 which are threaded in the bracket 21 in positions to bear against the thrust surface of plate 20. The arrangement includes four of the bolts 42 and also four of the adjusting screws 43 arranged toward the corners of a square, so that the brackets 21 can be adjusted angularly with respect to the plate 20 in any plane.

It is sometimes desired to obtain a curvature as illustrated in Figure 6. The arrangement of the apparatus to obtain a predetermined curvature as shown in Figure 6 is illustrated in Figure 7. It should, however, be noted that the curvature obtained in Figure 7 is 180° off-set from the curvature illustrated in Figure 6.

The apparatus described above in connection with Figures 1 to 8 inclusive is utilised in accordance with the present invention to provide a piece which is definitely curved in any plane of curvature desired. This is true, notwithstanding the fact that the lower crawler tread blocks 34 which interfit with the interior of the channel being formed, actually prevent curvature of the piece during its travel through the puller mechanism. When this apparatus is employed, as is contemplated according to the present invention, to impart a definite curvature to a piece, the adjustment of the position of the die structure 29—30 with respect to the puller mechanism should be such as to definitely provide the curvature desired. For example, referring to Figure 5, and assuming that the relative position of the die parts 29—30 and the roller mechanism as there shown are such as to counteract a tendency for production of a sway-back warpage such as shown in Figure 4, and to produce a channel having curvature in the opposite direction from that illustrated in Figure 4, the angularity of the die parts 29 and 30 would be increased from that shown in Figure 5 (i.e. the right hand end of the die parts would be lowered still further) in consequence of which this arrangement would produce a piece curved oppositely to the piece illustrated in Figure 4.

Similarly, referring to Figures 6 and 7 if it is desired to produce a piece having a curvature opposite to that illustrated in Figure 6, the inclination of the die parts would be further increased with reference to the line of pull of the puller mechanism, and this will produce a curvature opposite to that illustrated in Figure 6. This will occur notwithstanding the interfitting relation of the shoes or crawler gripping elements 34 between the flanges 28 of the channel. Although the crawler mechanism itself will constrain the piece to remain straight during passage through the puller mechanism, upon delivery of the piece from the exit end of the puller mechanism it will assume its curvature, depending upon the angle which is established between the axis of the passage through the die structure and the line of pull of the puller mechanism. When operating in this way, although the article is hardened or solidified within the die structure, nevertheless it is preferable not to excessively cool the article through the thickness thereof before the article actually leaves the die structure. In effect, the material retains, by elastic memory, a certain curvature "set" which is imparted to the material at the exit end of the die structure, and although the article is constrained

to remain straight as it passes through the puller mechanism, nevertheless that curvature reappears when the piece is delivered from the exit end of the puller mechanism.

In the embodiment illustrated in Figures 9, 10 and 11, the arrangement of many of the parts is essentially similar to that described above. Here, however, the crawler treads or gripping elements take a somewhat different form. In this instance the upper and lower gripping elements 44 and 45, which have surfacing or lining indicated at 46 preferably composed of a friction material such as rubber, are made of substantial dimension transverse to the line of pull, preferably being several times as wide as the width of the piece being formed. In this instance the piece is also illustrated as being a channel having web 47 and flanges 48, the web being wider and the flanges narrower than the channel illustrated in Figures 1 to 8. In this instance the lower blocks or gripping elements 45 do not interfit with the inside of the channel but merely bear against the lower edges of the channel flanges 48.

In view of the width of the gripping elements 44 and 45 with respect to the width of the piece being formed, the piece may creep laterally as it is being advanced by the crawler mechanism and in this way a sharper curvature may be developed than in the embodiment of Figures 1 to 8 inclusive. As before, the line of pull of the puller mechanism and the axis of the passage through the die structure are angled to each other, and as shown in Figure 10 this angularity is increased as compared with Figure 7 and provides for a shorter radius or sharper curvature. The puller mechanism is of course arranged in such position that gripping of the piece being formed is assured notwithstanding the fact that the curvature of the piece is developing as the piece is being pulled by the puller mechanism.

The shape of the crawler or gripping elements may also be modified so as to take the form indicated in Figure 12, which illustrates the formation of a relatively wide and large channel member having a base 49 and flanges 50. Here the upper and lower gripping elements 51 and 52 are made of considerably smaller transverse or lateral dimension than the distance between the flanges 50 of the channel, and here again creepage will occur as the piece is being advanced through the puller mechanism.

It will be understood that the shape of the gripping elements employed in the puller mechanism will depend upon the shape of the piece being made, which may take any of a variety of forms ranging all the way from a simple flat strip to a complex shape, either angular or curved or even tubular, the illustration herein of channel pieces being given only by way of example.

Preferably a thermosetting resin in liquid stage is employed, preferably a polyester laminating resin. Such a resin is advantageously used with a small quantity, for instance about 1% of a hardener such as benzol peroxide. A lubricant such as Carnauba wax may also be present.

As is known, polyester resins, sometimes also referred to as alkyd resins are formed by the reaction of a dibasic acid with a polyhydric alcohol. Those of the reaction products formed in this way which have unsaturation in the molecule are used in the formulation of thermosetting polyester resin materials, the unsaturated reaction product being used in combination with a cross linking agent, usually a monomer such as:

Styrene
Diallyl phthalate
Vinyl toluene
Methyl methacrylate
Triallyl cyanurate

Resin materials of the kinds referred to are relatively stable at room temperature and, depending upon the proportions of ingredients, comprise a more or less mobile liquid. When a quantity of the resin material is to be used in the process, a hardener or accelerator is also preferably present, for instance benzol peroxide, as mentioned hereinabove.

The resin material is placed in the reservoir 22 at room temperature or, in any event, well below the curing temperature of the resin. The circulation of cooling liquid through the passages 36 and 37 is arranged to maintain the temperature in the inlet end portion of the die well below the setting or curing temperature of the resin, desirably below about 130° F.

Heat is applied in the mid region of the die structure by means of the elements 38 and 39 and in this way the heating is advantageously effected to raise the temperature of the resin to a point above about 200° F., advantageously between about 220° F. and 400° F., which is a suitable range for the curing or setting of most resins of the type contemplated for use.

Some cooling is also contemplated under at least some circumstances by circulation of cooling liquid through the passages 40 and 41 in the exit end portion of the die structure, although the extent of cooling here employed would depend somewhat upon the size and shape of the piece being made and also upon the sharpness of curvature desired. In general the exit temperature of the piece should be higher where relatively shape curvature is contemplated and in many instances it has been

found that it is not necessary to cool the exit end of the die at all. In a typical operation the exit temperature of the piece should be below about 200° F. and preferably between about 160 and 200° F.

According to the invention it is possible to impart curvature to pieces being made even where the curvature occurs in the plane of a flat part of the piece, for instance in the plane of a strip or a channel member, such as illustrated in the drawings, and in the case of a channel, for instance about 1 to 2 inches in width, it is entirely practical to develop a curvature corresponding to a radius of from 10 to 20 feet.

Having regard to the provisions of Section 9 of the Patent Act, attention is directed to the claims of Patent No. 933,993.

WHAT WE CLAIM IS:—

1. A method for forming a continuous length of articles composed of fiber reinforced resin materials, which comprises the steps of impregnating the fiber reinforcements with a heat hardenable liquid resin material, feeding the impregnated fiber reinforcements into the entrance end portion of a confining passage, heating the resin material in at least a portion of the confining passage to a temperature sufficient to solidify the resin and pulling the solidified article beyond the exit end portion of the confining passage at an angle deviating from a straight line extended along the line of discharge of the hardened article from the exit end to impart to the article a desired curvature.

2. A method according to claim 1, in which the pulling is effected by gripping devices travelling in a path extending at said angle to the line of discharge of the hardened article from the exit end of the confining passage.

3. A method according to claim 2, comprising the step of permitting the article to creep laterally within the gripping devices to impart the desired curvature to the formed article.

4. A method for forming continuous lengths of curved articles substantially as herein described with reference to the accompanying drawings.

For the Applicants,
MATTHEWS HADDAN & CO.,
Chartered Patent Agents,
31 Bedford Street,
London, W.C.2.

Abingdon: Printed for Her Majesty's Stationery Office, by Burgess & Son (Abingdon), Ltd.—1966.
Published at The Patent Office, 25 Southampton Buildings, London, W.C.2,
from which copies may be obtained.

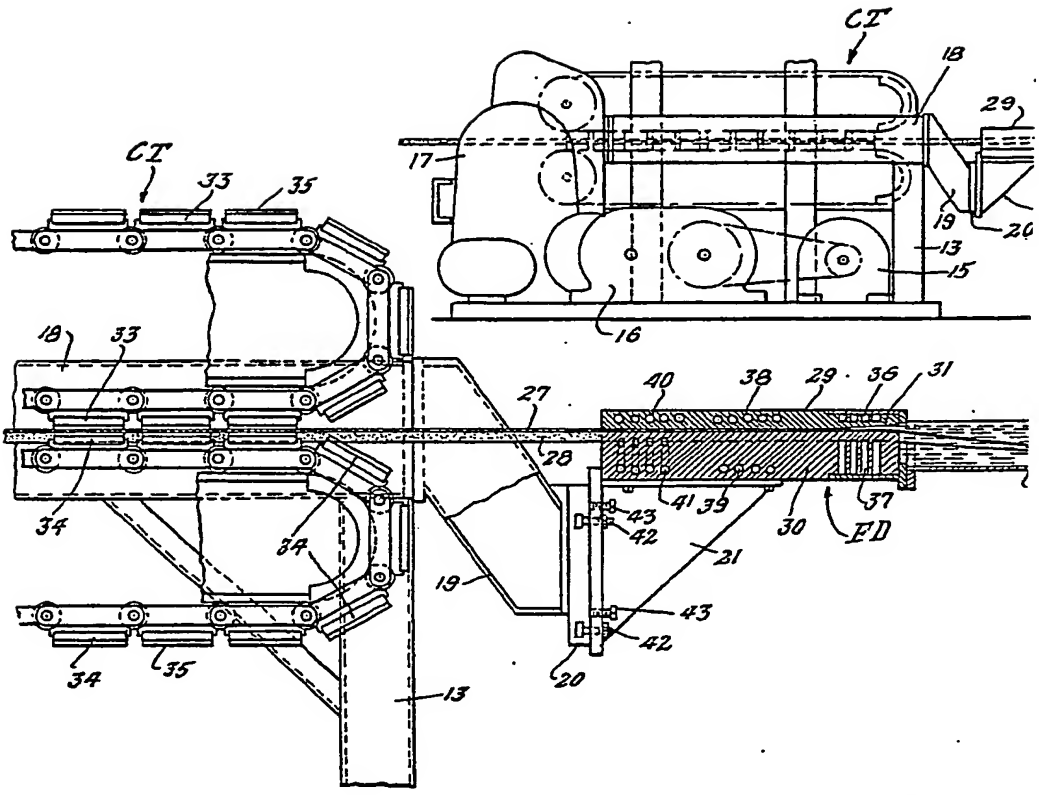
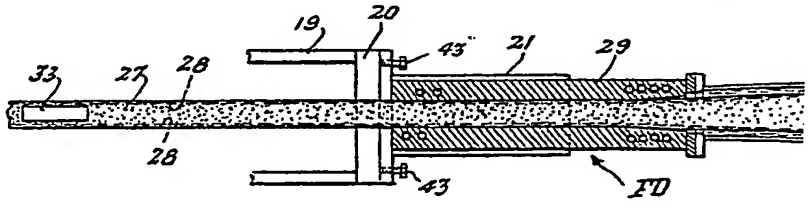


Fig. 3.



1044031 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

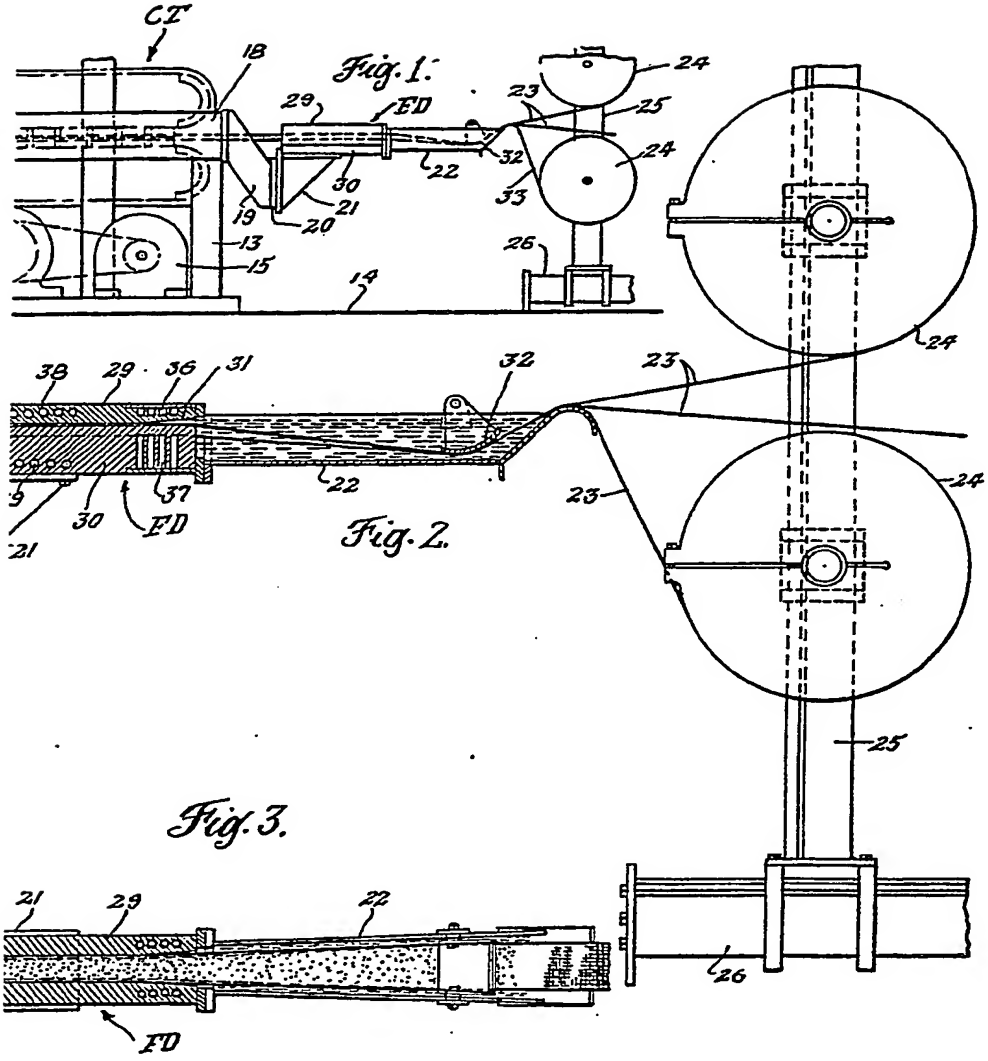


Fig. 1.

Fig. 2.

Fig. 3.

1044031 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

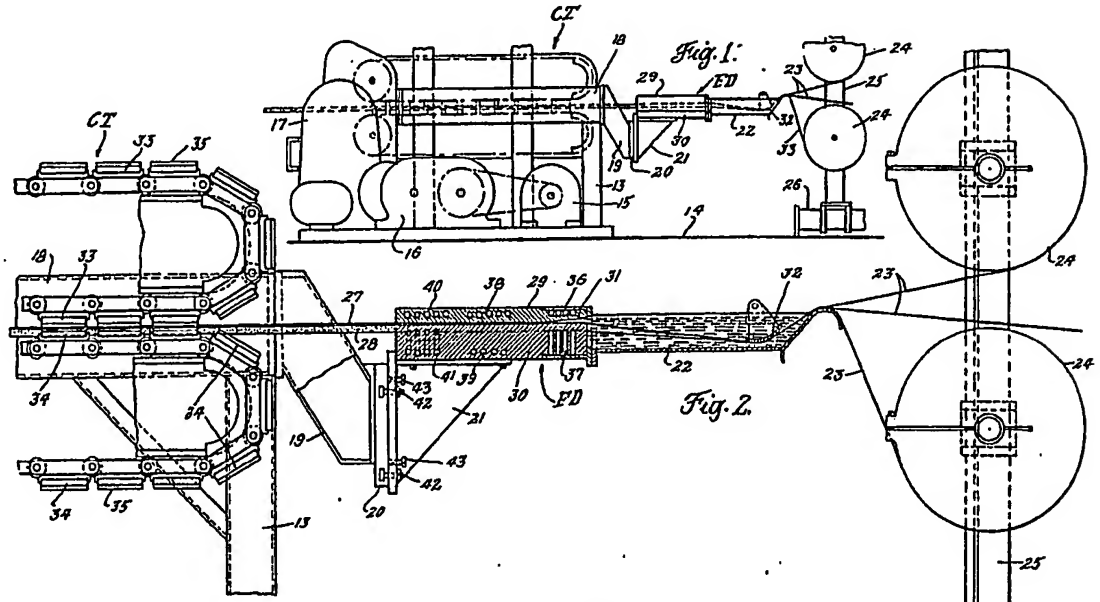


Fig. 1.

Fig. 2.

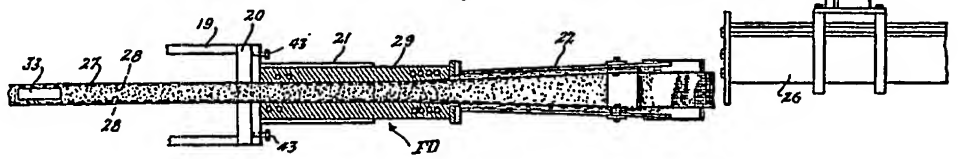


Fig. 3.

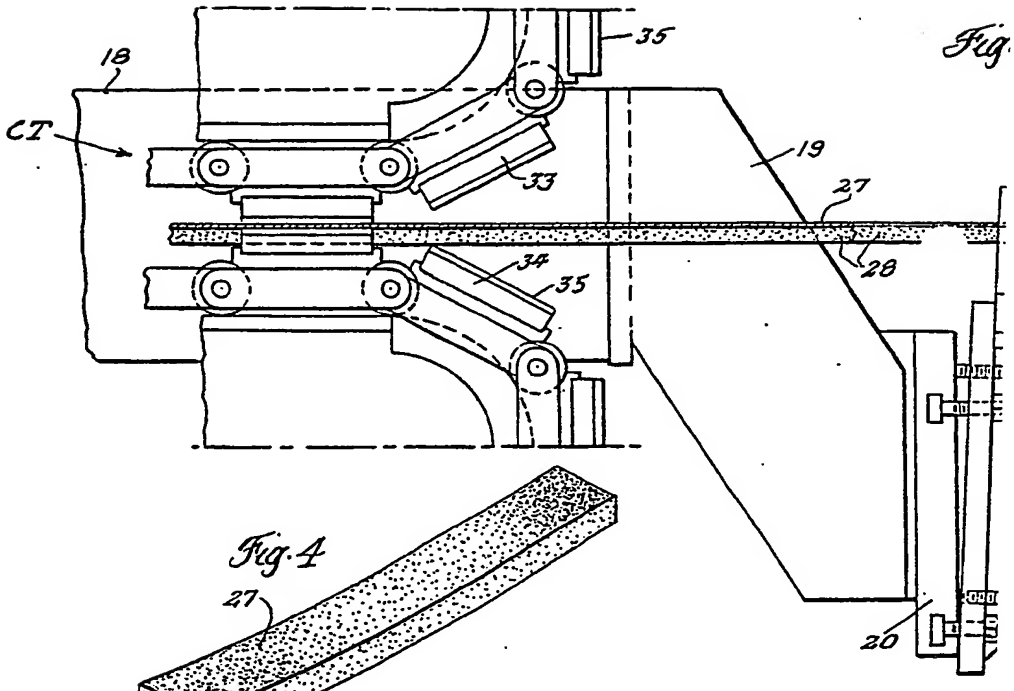
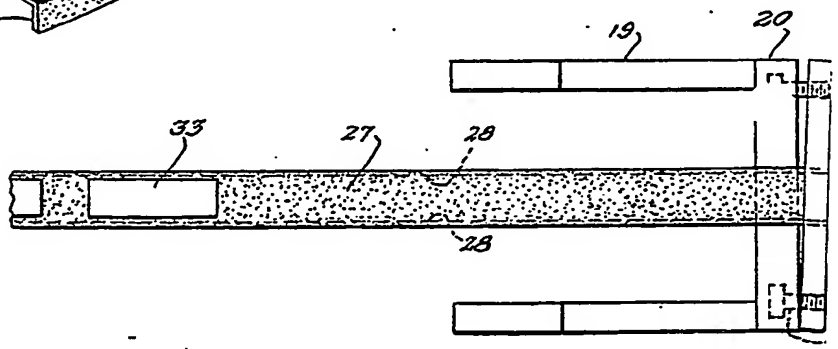


Fig.4



1044031 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

Fig. 5.

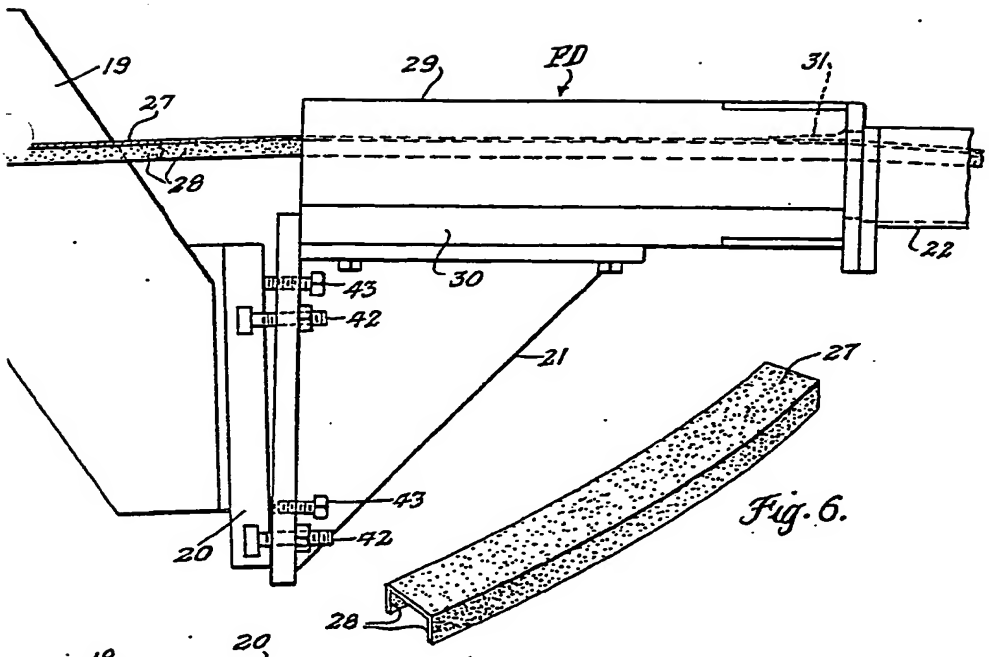


Fig. 6.

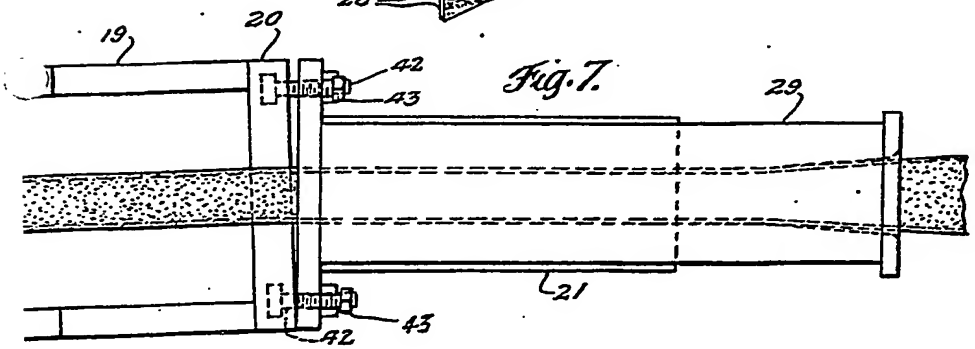


Fig. 7.

1044031 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

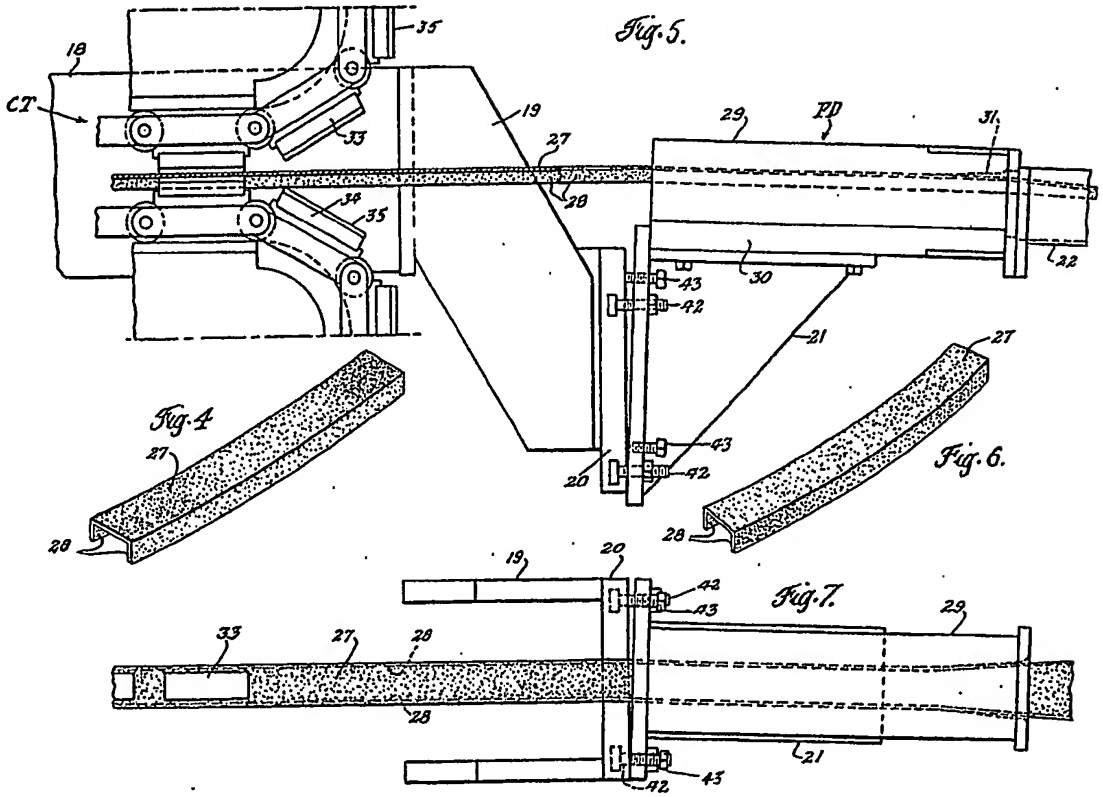


Fig. 5.

Fig. 4

Fig. 6.

Fig. 7.

Fig. 8.

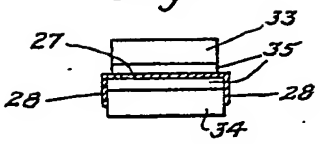


Fig. 11.

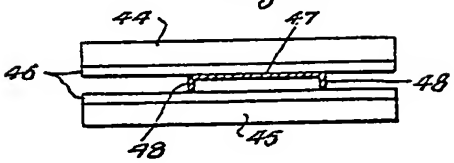
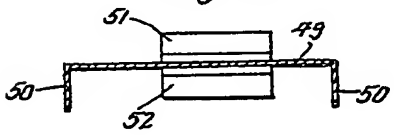
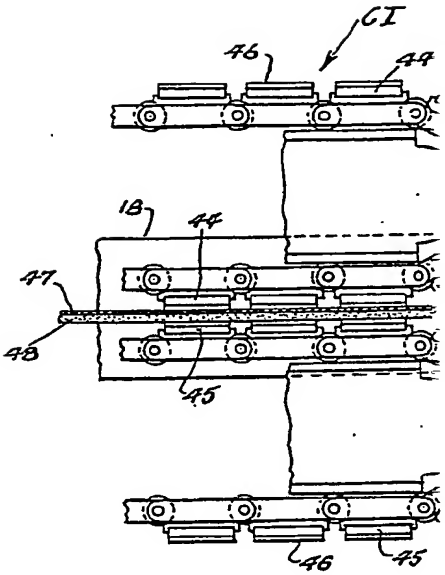
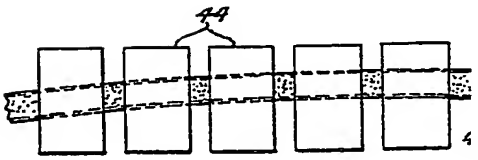


Fig. 12.







1044031 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

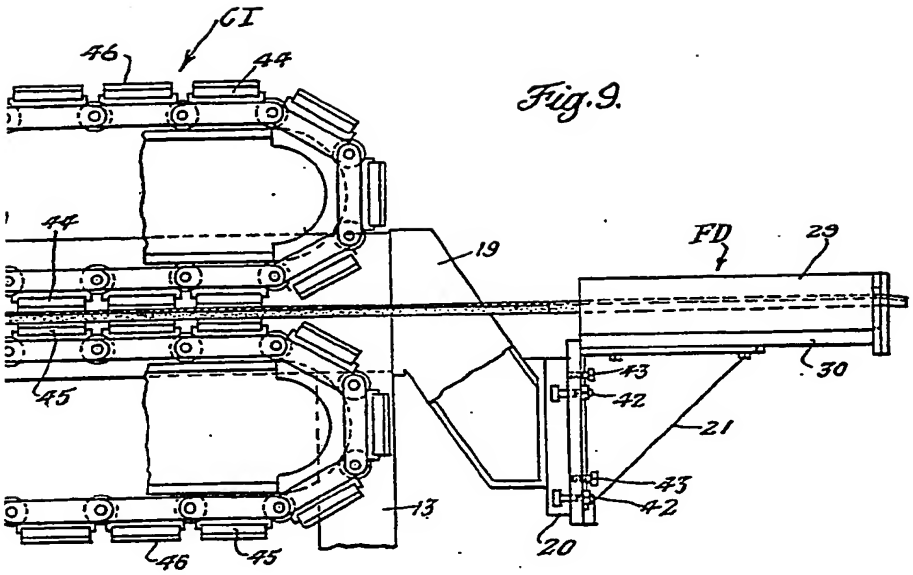
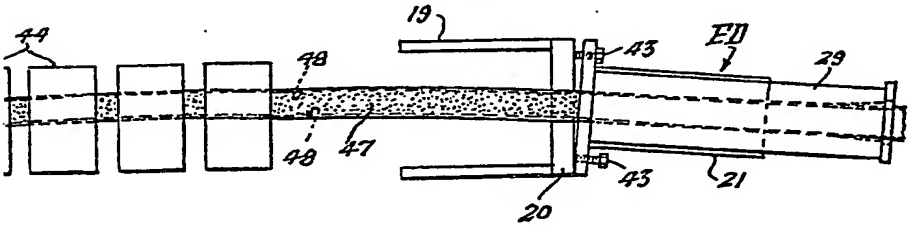


Fig. 9.

Fig. 10.



1044031 COMPLETE SPECIFICATION

3 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 3

Fig. 8.

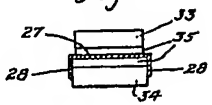


Fig. 11.

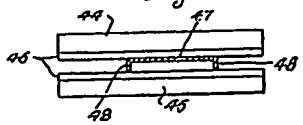


Fig. 12.

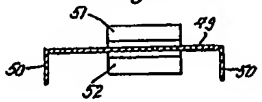


Fig. 9.

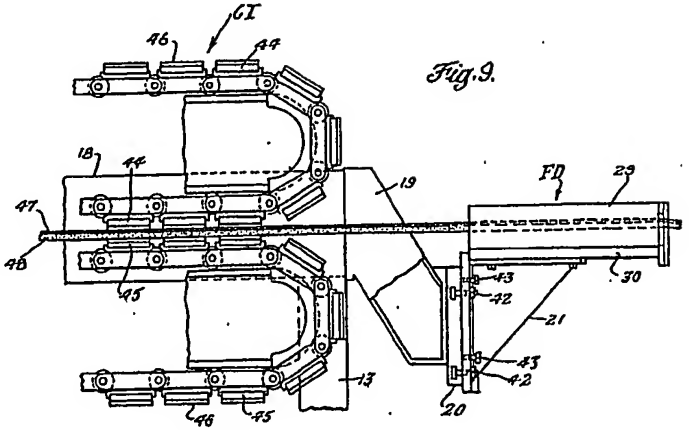


Fig. 10.